HW5_PartII_Vatic_SolarWindLoss

December 8, 2025

1 Part II (Vatic)

[1]:
```
from vatic.engines import Simulator
from vatic.data.loaders import load_input, RtsLoader
from vatic.engines import Simulator

import pandas as pd
import numpy as np

from pathlib import Path
import dill as pickle
import os
from datetime import datetime
import matplotlib.pyplot as plt

import warnings
warnings.filterwarnings("ignore")
```

[2]:
```
grid_name = "Texas-7k"
RUC_MIPGAPS = {grid_name: 0.01}
SCED_HORIZONS = {grid_name: 4}
grid = grid_name  #For Texas, put 'Texas-7k' or 'Texas-7k_2030'
num_days = 1
init_state_file = None

def get_input_for_simulation(date):
    start_date = date #For Texas pick a date in 2018
    template, gen_data, load_data = load_input(grid, start_date,␣
 ↪num_days=num_days, init_state_file=init_state_file)
    return template, gen_data, load_data, start_date
```

[3]:
```
CO2_data = pd.read_csv("emissions_CO2.csv")
dates = ["2018-01-19", "2018-07-19"]
scenario_index_to_name = {1: "baseline", 2: "cloudy", 3: "wind_equivalent"}
```

1.0.1 Baseline Simulation

[7]:
```
siml = Simulator(template, gen_data, load_data, None,
                 pd.to_datetime(start_date).date(), 1, solver='gurobi',
                 solver_options={}, run_lmps=False, mipgap=RUC_MIPGAPS[grid],
                 load_shed_penalty = 1e4, reserve_shortfall_penalty = 1e3,
                 reserve_factor=0.05, output_detail=3,
                 prescient_sced_forecasts=True, ruc_prescience_hour=0,
                 ruc_execution_hour=16, ruc_every_hours=24,
                 ruc_horizon=48, sced_horizon=SCED_HORIZONS[grid],
                 lmp_shortfall_costs=False,
                 enforce_sced_shutdown_ramprate=False,
                 no_startup_shutdown_curves=False,
                 init_ruc_file=None, verbosity=0,
                 output_max_decimals=4, create_plots=False,
                 renew_costs=None, save_to_csv=False,
                 last_conditions_file=None,)
report_dfs = siml.simulate()
```

```
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be removed in (or after) 7.0) (called from /home/pl7830/.conda/envs/vatic-
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test/lib/python3.11/site-
packages/egret/model_library/unit_commitment/startup_costs.py:130)
Calculating PTDF Matrix Factorization
WARNING: DEPRECATED: The quicksum(linear=…) argument is deprecated and
ignored.  (deprecated in 6.6.0) (called from /home/pl7830/.conda/envs/vatic-
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```

```
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```

[8]:
```
import pickle
with open("report_dfs.pkl", "wb") as f:
    pickle.dump(report_dfs, f)
```

[39]:
```
thermal_detail = report_dfs["thermal_detail"].reset_index()
thermal_detail_co2 = pd.merge(thermal_detail, co2_data, left_on = "Generator",␣
 ↪right_on = "GEN UID", how = "inner")
# Dispatch assumed to be in MWh
thermal_detail_co2["CO2_Total"] =␣
 ↪thermal_detail_co2["Dispatch"]*thermal_detail_co2["CO2 Emissions Lbs/MWh"]
thermal_detail_co2["CO2_Total"].sum()
```

[39]:
```
np.float64(1063377974.6755733)
```

1.0.2 Matching solar loss with equivalent wind loss

[4]:
```
def get_actual_energy_columns(df, etype):
    output = []
    for col in df.columns:
        if(etype in col[1] and col[0] == "actl"):
            output.append(col)
    return output

def get_p_value(df):
    solar_cols = get_actual_energy_columns(df, 'Solar')
    wind_cols = get_actual_energy_columns(df, 'Wind')
    solar_sum = sum(df[solar_cols].sum(axis=1))
    wind_sum = sum(df[wind_cols].sum(axis=1))
    print(solar_sum, wind_sum)
    p = (solar_sum * 0.75) / wind_sum
    return p

def change_generation_data(gen_data, scenario):
    if(scenario == 2): # cloudy day
        solar_cols = get_actual_energy_columns(gen_data, "Solar")
        gen_data[solar_cols] *= 0.25
    elif(scenario == 3): # wind equivalend
        wind_cols = get_actual_energy_columns(gen_data, "Wind")
        p = get_p_value(gen_data)
        print("p value", p)
        gen_data[wind_cols] *= (1-p)
    return gen_data

def convert_lbs_to_metric_tons(x):
    '''
    Converts a value in lbs to metric tons
    '''
    return x/2204.6223
```

[5]:
```
for date in dates:
    template, gen_data, load_data, start_date = get_input_for_simulation(date)
    for scenario in [1, 2, 3]:
        gen_data_modified = change_generation_data(gen_data, scenario)
        scenario_name = scenario_index_to_name[scenario]
        print(date, scenario_name, "Started!")
        siml = Simulator(template, gen_data_modified, load_data, None,
                    pd.to_datetime(start_date).date(), 1, solver='gurobi',
                    solver_options={}, run_lmps=False, mipgap=RUC_MIPGAPS[grid],
                    load_shed_penalty = 1e4, reserve_shortfall_penalty = 1e3,
```

```
                    reserve_factor=0.05, output_detail=3,
                    prescient_sced_forecasts=True, ruc_prescience_hour=0,
                    ruc_execution_hour=16, ruc_every_hours=24,
                    ruc_horizon=48, sced_horizon=SCED_HORIZONS[grid],
                    lmp_shortfall_costs=False,
                    enforce_sced_shutdown_ramprate=False,
                    no_startup_shutdown_curves=False,
                    init_ruc_file=None, verbosity=0,
                    output_max_decimals=4, create_plots=False,
                    renew_costs=None, save_to_csv=False,
                    last_conditions_file=None,)
        # Computation
        report_dfs = siml.simulate()
        with open(f"report_dfs_{date}_{scenario_name}.pkl", "wb") as f:
            pickle.dump(report_dfs, f)
        print(date, scenario_name, "Finished!")
        print("")
```

```
31324.076762651617 505316.56833711837
p value 0.04649176188562154
2018-01-19 wind_equivalent Started!
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Warning for adding constraints: zero or small (< 1e-13) coefficients, ignored
Warning for adding constraints: zero or small (< 1e-13) coefficients, ignored
2018-01-19 wind_equivalent Finished!

50785.63020434008 391233.68739672063
p value 0.09735670490622052
2018-07-19 wind_equivalent Started!
Warning for adding constraints: zero or small (< 1e-13) coefficients, ignored
Warning for adding constraints: zero or small (< 1e-13) coefficients, ignored
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```

```
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Truncating shutdown_curve longer than scaled minimum down time 1 for generator
50304_AllOther_GEN2
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50304_AllOther_GEN2
Truncating shutdown_curve longer than scaled minimum down time 1 for generator
50304_AllOther_GEN2
2018-07-19 wind_equivalent Finished!
```

[5]:
```
# Computing CO2 Emissions
CO2_df = pd.DataFrame(columns = ["date", "scenario_name", "CO2 Emissions (in␣
 ↪MT)"])
row = 0
for date in dates:
    for scenario in [1, 2, 3]:
        scenario_name = scenario_index_to_name[scenario]
        # Fetching the stored pickle files
        with open(f"report_dfs_{date}_{scenario_name}.pkl", "rb") as f:
            report_dfs = pickle.load(f)
        # Extracting thermal details
        thermal_detail = report_dfs["thermal_detail"].reset_index()
        thermal_detail_CO2 = pd.merge(thermal_detail, CO2_data, left_on =␣
 ↪"Generator", right_on = "GEN UID", how = "inner")
        # Dispatch assumed to be in MWh
        thermal_detail_CO2["CO2_Total"] =␣
 ↪thermal_detail_CO2["Dispatch"]*thermal_detail_CO2["CO2 Emissions Lbs/MWh"]
        CO2_total = thermal_detail_CO2["CO2_Total"].sum()
        CO2_total = convert_lbs_to_metric_tons(CO2_total)
        print(date, scenario_name, CO2_total)
        CO2_df.loc[row] = [date, scenario_name, CO2_total]
        row += 1
        print("")
```

```
2018-01-19 baseline 482340.20615484717

2018-01-19 cloudy 486732.5932620959

2018-01-19 wind_equivalent 487034.04493126826
```

```
2018-07-19 baseline 677450.4814349589

2018-07-19 cloudy 684518.494041032

2018-07-19 wind_equivalent 686277.0734749862
```

[6]:
```
# temp = CO2_df.set_index(["date", "scenario_name"])
CO2_df["base_emissions"] = 0
for date in dates:
    val = CO2_df[(CO2_df["date"] == date) & (CO2_df["scenario_name"] ==␣
 ↪"baseline")]["CO2 Emissions (in MT)"].iloc[0]
    CO2_df.loc[CO2_df["date"] == date, "base_emissions"] = val
CO2_df["pct_change"] = (CO2_df["CO2 Emissions (in MT)"] -␣
 ↪CO2_df["base_emissions"])*100/CO2_df["base_emissions"]
CO2_df
```

[6]:

	date	scenario_name	CO2 Emissions (in MT)	base_emissions	\
0	2018-01-19	baseline	482340.206155	482340.206155	
1	2018-01-19	cloudy	486732.593262	482340.206155	
2	2018-01-19	wind_equivalent	487034.044931	482340.206155	
3	2018-07-19	baseline	677450.481435	677450.481435	
4	2018-07-19	cloudy	684518.494041	677450.481435	
5	2018-07-19	wind_equivalent	686277.073475	677450.481435	

	pct_change
0	0.000000
1	0.910641
2	0.973139
3	0.000000
4	1.043325
5	1.302913

As seen, CO2 emissions increase in both cases when the solar or the wind generation is curtailed. Further, the increase is more in case of wind curtailment (0.97% vs 0.91%, 1.30% vs 1.04%) as compared to solar curtailment, indicating that wind saves a lot of CO2 from being emitted while fulfilling the demand! (Note that generation was only changed on the actual columns.)